SOIL CONSERVATION

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EROSION DEFENSES WITHSTAND POUNDING OF RECORD RAINS

By Harold G. Anthony

The manner in which complete coordinated erosion-control measures on land of cooperating farmers with the Soil Conservation Service in the Plum Creek demonstration project withstood torrential rains and flood waters last night was remarkable.

That's the wording of a telegram received on the afternoon of July 7 from W. H. Du Puy, of Lockhart, Tex., project manager of the area comprising Caldwell and Hays Counties.

Let it be said right here that Mr. Du Puy's telegraphic message was an understatement.

I arrived at Lockhart 24 hours after an 8.38-inch rain had fallen in a matter of 6 hours. This was the heaviest downpour since 1902 and through one period of 20 minutes it reached a maximum intensity of 4 inches per hour. Plum Creek went raging out of its banks and 13 lives were claimed by the unleashed waters in and around the villages of Uhland and Kyle, in the heart of the project area. Other rains during the day preceding my arrival brought the total precipitation to well over 9 inches.

Accompanied by other staff members I went for a first-hand look at the erosion-control program under the strain of such a test.

Unrestrained Waters at Work

Now, I want you to come along with me. Get the picture.

We are sitting in our car, 4 or 5 inches of water swirling over the highway, near the little community of Uhland. On our right is a farm totally unprotected from erosion. Nearest us is a large, sloping field planted to cotton and corn. Between every two rows is a stream of muddy water rushing toward the roadside ditch. As we watch, we see the water cutting loose soil, gouging out holes. We see small gullies between the furrows turning into gaping gashes in the cultivated field. We see furrows disappearing, melting into the water. On the lower edge of the field there is a deposition of topsoil, washed from the slope above, gradually growing deeper, spreading out, relentlessly covering growing cotton and building up around stalks of corn. In many instances cotton is being uprooted—dug out by the rapidly flowing water.

What we see here is not only the virtual destruction of a cotton crop. More serious and far-reaching is the fact that here is the wasting away by water erosion of good farm land that will never again—certainly not in several generations—reach its former peak of productivity. The very life of the land, tons and tons of rich topsoil, is being washed away, never to be returned except through the slow processes of nature.

Multiply the scene by a hundred, yes, even a thousand, and you will have some idea of the destruction wrought by a single cloudburst on acre upon acre of unprotected land in the watershed of

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Two-foot deposit of soil covers cotton at left. This unprotected field furnishes evidence of tremendous soil movement by water.

Huge silt deposit made by soil swept from unprotected field.

Portion of roadway on Siley Valley highway swept away for distance of 150 feet by flood waters.

A–1 bottom land at Uhland, Tex. Scoured out to hard subsoil, entailing loss of 6 to 8 inches of good topsoil over entire field. Field above protected by vegetation and contour ridges suffered no damage from washing or gullying.

Plum Creek. Add to this, also, the loss of life, the damage to highways and railways, the destruction of homes, and you will readily agree that if the more extensive application of proper erosion-control measures could have prevented even one-tenth of the tragedy, the expense and effort would have been well worth while.

By Way of Contrast

Now let's look at another farm. We are still near Uhland in the Plum Creek demonstration area. The farm we now see is under cooperative agreement and the complete, coordinated erosion-control program has been instituted on each acre.

Stretching out across one of the fields is a well-planned system of sorghum strip crops. Instead of water sweeping tons of topsoil off this field we see each contoured furrow filled with water that is gradually finding its way to a lower level. Water flowing into the strips of sorghum is so slowed down by the fibrous-rooted plants that it actually backs up above the strip. Soil held in suspension is dropped. A close inspection of water coming from the strip nearest the road reveals that it is clear, free of soil. The water runs out from the strip slowly, evenly, and does not cut or wash.

On a field of the farm having a slope of about 4 percent we see in addition to strip crops and contour cultivation a system of wide base Mangum terraces. The terraces, almost filled to the top with water, are unbroken. Excess water is flowing slowly through vegetated outlets into a well-sodded channel that delivers it safely to stream level.

Holding on Hillside

There is a third field with a still steeper slope. This is a new pasture—land too steep for safe cultivation. Grass and contour ridges are doing a perfect job of holding the water on the hillside, thereby cutting the

Two- to three-foot deposit of silt formed by soil swept from unprotected field. Original height of corn about 6 feet.

rate of run-off to a minimum. There is no apparent erosion on this hillside.

What we have seen, of itself, needs little elaboration. It is an actual and enlightening contrast of farm lands unprotected by erosion-control measures with a farm under the erosion-control program of the Soil Conservation Service. The pictures just described could be duplicated in any part of the Plum Creek demonstration area.

Mr. Du Puy pointed out to me that any farmer could apply the same erosion-control measures to his land as are being instituted cooperatively here on more than 10,000 acres in the area. Said he:

> This work is as simple as it is effective. Our program of erosion-control measures is built around the use of vegetation and proper cultural practices, with engineering devices used only where they are absolutely necessary. Cover crops, well-planned rotations, and contour cultivation are all integral phases of our program. These cultural practices, with strip crops and terraces where necessary, and the handling of excess run-off water by the use of sodded channels, by meadows strips, or by dumping it onto well-sodded pastures, all work together to cut erosion hazards to a minimum on cultivated areas.
>
> The proper use of each acre of the land is, of course, the foundation of our program. Steep slopes cannot be safely cultivated, so such areas are retired and put into pasture or woodland when that is practicable. Once sod, pasture grasses, or trees become established on steep slopes, there is little danger of erosion. On pasture lands the farmer builds contour ridges which hold the water, furnishing moisture for the grasses, as well as slowing run-off.

From the flood-control angle, erosion-control measures are of great importance, Mr. Du Puy pointed out. Every phase of the coordinated erosion-control program is directed toward holding water on the land so that it will have an opportunity to soak into the ground and so that excess water will run off slowly and without scouring, washing, or undue concentration. Floods are nothing more than the result of a

(Continued on p. 57)

Clear water coming from strip crop. In this 84-acre field are 22 acres of strips, each averaging 20 feet in width. A strip of alfalfa at upper end of field was plowed under before flood, that portion showing erosion afterward.

Terrace holding water. At lower left may be seen water flowing through vegetated outlet into well-sodded channel. No erosion on this field. Terrace to be stripped with peas.

Deposit of silt just above strip crop of redtop sorghum. Strip proved effective in slowing flow of water and causing soil in suspension to be dropped. Note water continuing to flow into strip.

Silt deposit above Hubam strip. This is a 24-acre field with 6 acres in strips. Maximum slope length 700 feet, average degree of slope 2½ percent, average strip width 25 feet. Hubam clover, alfalfa, peas, Sudan, and sorghum are favored for strips.

Sodded outlet channel. It not only carried big flow of water from terraced field but also caught water which flooded over highway. No scouring, cutting or silting whatever in channel.

STOCK PONDS IN THE GREAT PLAINS DROUGHT AREA

By W. C. Lowdermilk [1] and F. F. Barnes [2]

Farm reservoirs were empty. Tracks in the dried mud bottoms mutely told of the vain search of thirsty cattle for water. Out of scores of reservoirs in western Kansas inspected during the drought of 1934, only one was found capable of moistening a parched throat. In normal times these basins—whether man-made or natural—supplied water for the farm stock, but during the drought their bounty quickly disappeared and it became necessary to rely on wells for both man and beast. Here, too, the reserves were rapidly exhausted, and serious shortages ensued.

There is a definite relationship between soil conservation and water conservation. An examination of many of the dry ponds by the senior author disclosed a few simple facts which had been overlooked in their location and design—considerations which, accorded proper attention, would have assured a supply of water during the urgency of drought.

Evaporation Overlooked

It was first apparent that the evaporation loss from a free water surface during the warm season had been overlooked in the design of the now-waterless reservoirs. The draft on a reservoir for livestock in the Plains is a small fraction of the evaporation loss. Without evaporation loss an acre-foot of water will water for a year 100 head of stock requiring about 10 gallons per head per day. But evaporation loss from a free water surface would be 4 to 5 feet from April to October—five or more times the water requirements

[1] Associate Chief, Soil Conservation Service.
[2] Division of Research, ibid.

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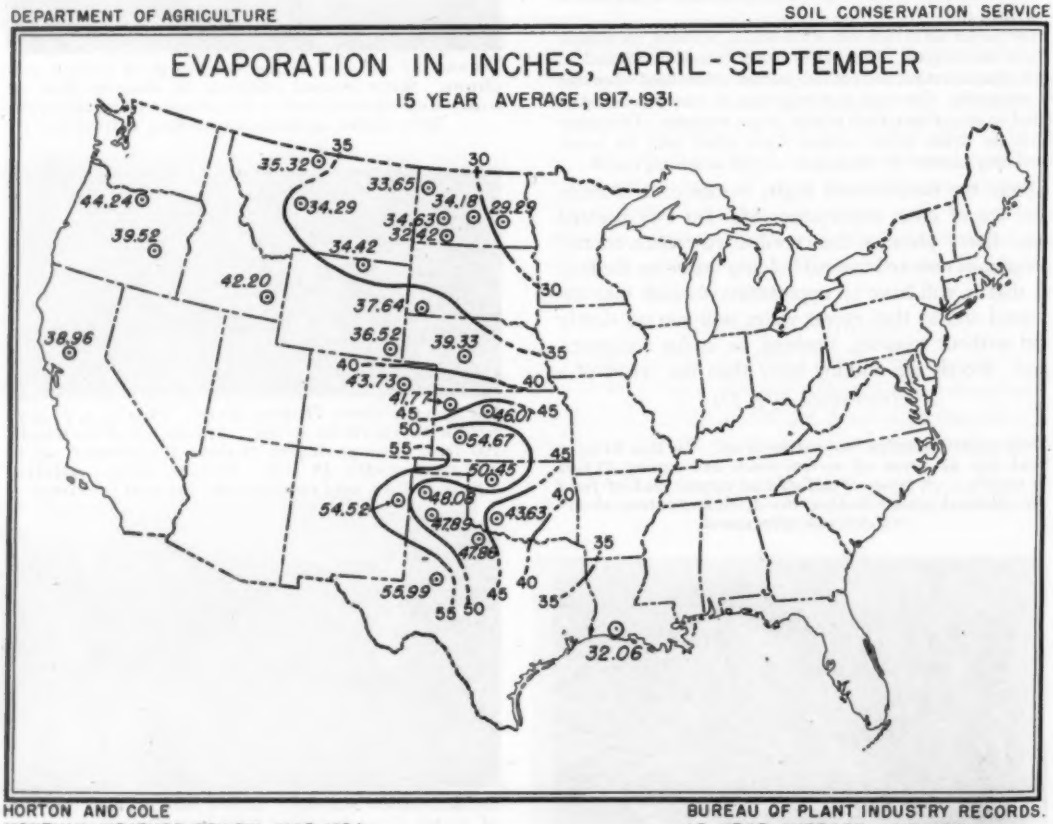

HORTON AND COLE
MONTHLY WEATHER REVIEW, MAR. 1934

BUREAU OF PLANT INDUSTRY RECORDS.
15 YEAR AVERAGE, 1917-1931

of stock. Unless the stock reservoirs or ponds were deep enough to allow for evaporation losses, it mattered little as to their total capacity—when dried by drought. As a general rule, a depth of double a season's evaporation loss would be a safe provision. Other considerations must likewise be had in the design and location of farm reservoirs or ponds. These will be more fully enumerated below.

A Timely Demonstration

The disastrous drought of July 1936 in the central and northern Great Plains emphasized the need for immediate action in providing adequate water supplies for livestock and other farm purposes. One of the most effective means of combating the tolls of drought is the construction of widely distributed and properly designed small reservoirs and farm ponds, which will store run-off from storm waters for use during prolonged dry periods. **Great material benefit is being derived from approximately 350 such reservoirs constructed in North Dakota, the heart of the drought area, between 1933 and 1935 by C. C. C. camps.** It is anticipated that this program will serve as a demonstration of the value to be derived from the widespread construction of such storage basins wherever natural conditions will permit, and that farmers in all sections of the affected area will aid in extending the work.

The cheapest and most practicable type of reservoir in most cases is formed by constructing an earthen dam, which may be built directly across a drainage line or may enclose an artificial depression to be filled by a diversion ditch or pipe line from a natural stream or drainage way. The cost of such reservoirs varies widely with the size and with local conditions. **For the program in North Dakota $150 per acre-foot (325,850 gallons) of storage space has been set as the maximum cost allowable. Most of the cost, however, represents labor**

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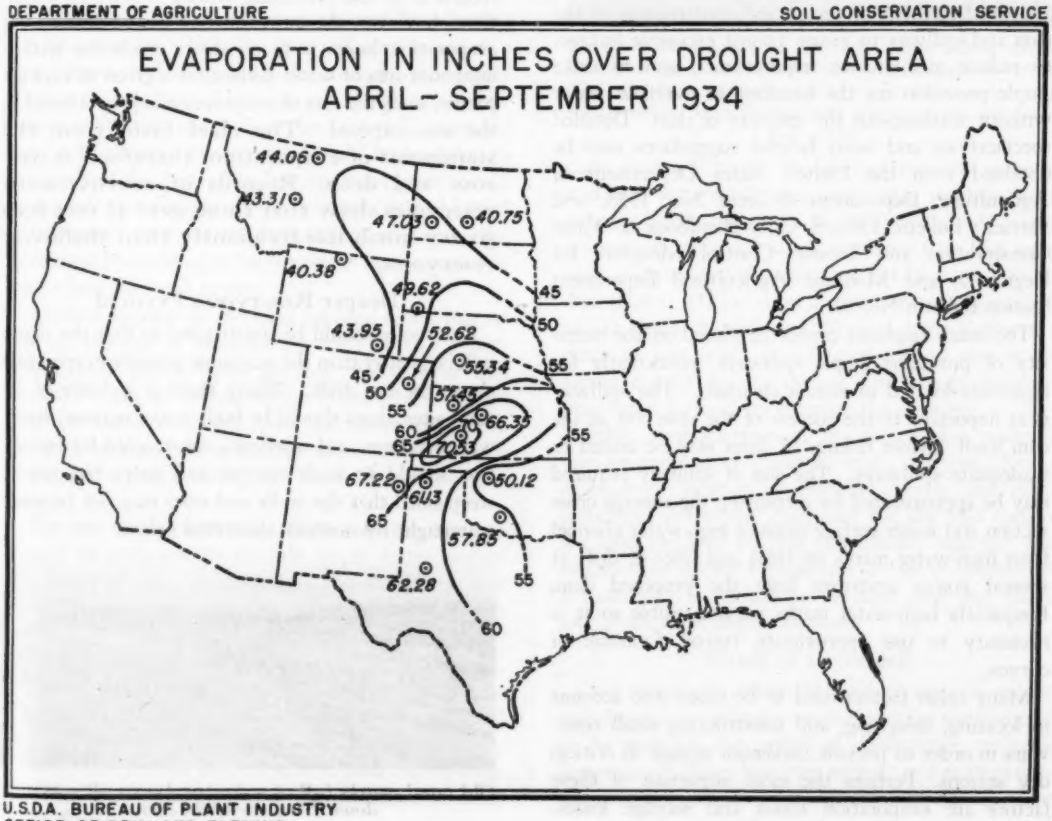


U.S.D.A. BUREAU OF PLANT INDUSTRY
OFFICE OF DRY LAND FARMING

One of the few ponds in Kansas that did not go dry during the season of 1934.

and equipment which the farmer himself is usually able to supply. Investment of his spare resources in pond construction during slack seasons will frequently be more than offset in a short time by savings from stock losses during droughts.

The success of any reservoir depends on the use of approved methods of design and construction of the dam and spillway to insure against excessive leakage, to reduce maintenance requirements, and to make ample provision for the handling of overflow water without washing out the spillway or dam. Detailed specifications and many helpful suggestions may be obtained from the United States Department of Agriculture, Department Bulletin No. 1358, and Farmer's Bulletin 1703, S. C. S. Handbook of Water Conservation and Erosion Control Measures for Region 9, and Montana Agricultural Experiment Station Bulletin No. 301.

Too much emphasis cannot be placed on the necessity of providing ample spillways, particularly for reservoirs located in stream channels. The spillway is as important to the success of the reservoir as the dam itself. Most failures of dams may be traced to inadequate spillways. The size of spillway required may be approximated by estimating the average cross section and water-surface slope of high-water channel from high-water marks on trees and lines of drift at several points upstream from the proposed dam. Frequently high-water marks are not visible so it is necessary to use approximate run-off formulae or curves.

Many other factors need to be taken into account in locating, designing, and constructing small reservoirs in order to provide maximum storage in critical dry seasons. Perhaps the most important of these factors are evaporation losses and seepage losses. Evaporation losses are particularly vital in regions of low humidity and high temperatures as typified by the drought country, and are commonly overlooked in planning reservoirs.

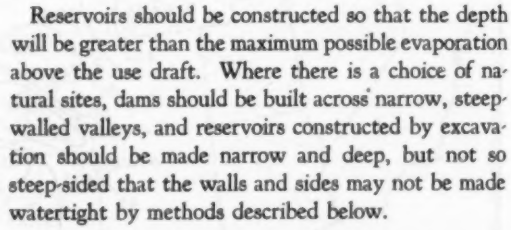
Annual Evaporation Figures

Data collected in various parts of the Midwest by the Bureau of Plant Industry show that the annual evaporation from water surfaces from April to September averages around 30 inches in the eastern Dakotas, 50 inches along the Kansas-Oklahoma boundary, 45 inches in southern Oklahoma, and 55 inches in central Texas. These averages may be exceeded by 50 percent during drought periods. Since these figures greatly exceed the run-off of storm waters in the respective regions, it is important that steps be taken wherever possible to reduce loss by evaporation.

The reservoir may be located so that trees or steep slopes shelter it from hot dry winds, and, if possible, the long axis of the reservoir should be selected to lie crosswise to the prevailing winds. Under all conditions, however, the most effective means of reducing evaporation losses is to construct reservoirs with a minimum area of water surface for a given storage capacity, since the rate of evaporation is proportional to the area exposed. **The ideal basin from the standpoint of evaporation, therefore, is narrow and deep. Records of southwestern reservoirs show that those over 12 feet deep go dry much less frequently than shallower reservoirs.**

Deeper Reservoirs Favored

Reservoirs should be constructed so that the depth will be greater than the maximum possible evaporation above the use draft. Where there is a choice of natural sites, dams should be built across narrow, steep-walled valleys, and reservoirs constructed by excavation should be made narrow and deep, but not so steep-sided that the walls and sides may not be made watertight by methods described below.



Old pond nearly full of sediment due to silt washing down from cornfield above.

A second important factor to consider in locating and designing reservoirs is loss of water by seepage. Experience has shown that loss from seepage is even greater than that from evaporation unless careful measures are taken to prevent the water from percolating away through the ground. This is best done by choosing a site underlain by clay-grit, a compact mixture of about one part of clayey material to two or three parts of sand and gravel. Such a soil is more watertight and substantial than pure clay, and, fortunately, is common over wide areas of the Plains. If the site is to be excavated, which is often desirable to obtain greater depth, the clay-grit should preferably be thick enough to allow for the excavation without exposing either a fissured bed rock or, what is more common in the Great Plains area, porous beds of sand and gravel; or, if the clay-grit is not thick enough for this, the bottom and sides may be surfaced with suitable material of excavation.

Reducing Seepage

Seepage in a new reservoir is reduced by plowing up the strip on which the dam will rest to secure a good bond, and by packing the earth-fill thoroughly during construction of the dam. If the fill is not composed of suitable materials, a clay-core wall, extended well into impervious material, should be provided in the body of the dam. The bottom of the basin should be packed thoroughly. If the water is not to be used for domestic purposes, the best method of packing the bottom is by bedding or feeding stock on the reservoir site when the earth is wet.

Marked success in reducing seepage losses has attended the use of bentonite, a form of clay which swells very greatly upon wetting. Deposits of this material occur in several of the Great Plains States. The bentonite is dusted into the water above the point of leakage, and is quickly drawn into the pore spaces of the underlying soil to form a watertight layer.

The size of the watershed above the reservoir site should be sufficient to provide ample water within the limits of climatic conditions. In the Plains area of Montana and Wyoming, 3 square miles of drainage area for each acre-foot of reservoir capacity is desirable to secure a stable water level. In the Dakotas, the figure is 1½ square miles. On the other hand, the area should not be so large as to offer a constant flood menace to small dams such as are constructed. In general, the farther downstream a reservoir is from the headwaters the greater is the likelihood of damaging floods.

Watersheds or catchment basins that are overgrazed or otherwise subjected to gullying and sheet erosion should be avoided until amply protected by a new growth of vegetation, for a reservoir fed by such an area would soon be filled with eroded soil from the slopes above. Since a certain amount of erosion occurs, even under normally favorable watershed conditions, steps should be taken to retard the filling of the reservoir with mud. Possible measures include: (1) Reduction or abandonment of grazing or tillage in the drainage basin, which may be held as emergency range or pasture. This is done most effectively by fencing both the reservoir and the watershed, and providing stock-watering troughs below the dam. (2) Settling basins, grassed waterways, or check dams upstream from the reservoir. These stop the sediment before it reaches the main basin. (3) Location of the reservoir to one side of the main channel and filling it from a diversion ditch or pipe line. In this way a flood gate in the feeder can be opened during floods to prevent the mud-laden water from entering the reservoir.

Earthen dam built to control large active gully. The fencing is to prevent possible damage by stock. The 300-foot spillway carries overflow water to a well-sodded, slightly wooded slope outside the original gully.

Other considerations in the choice of a reservoir site are the ease of access to stock, the possibility of satisfactory location of troughs, corrals, and other structures below the dam, and the size and cost of the dam required to give the desired storage. The largest capacity for a given size of dam is obtained in a basin that is narrow at the dam site and has a nearly flat slope above the dam.

Needs of Livestock

Once the site is chosen, the size of reservoir needed will depend on the water requirements of the livestock to be watered, the period of dependence, probable frequency of filling, loss from seepage and evaporation, and danger of reduction in capacity from silting. The

(Continued on p. 58)

A CLOSE-UP OF BUFFALO GRASS, NATIVE OF THE GREAT PLAINS

By Guy C. Fuller [1]

A single plant of buffalo grass.

No exotic or indigenous species of grass has been found more fully adapted to the heavier soil types of the western Great Plains area than buffalo grass (*Buchloe dactyloides*).

It may be noted, parenthetically, that the Soil Conservation Service has been in operation for a sufficient period of time to determine that vegetation, in most cases, is the most effective and economical weapon to employ for combatting soil erosion and for conserving moisture. Attention is being focused upon the use and development of those vegetative types most effective in soil and moisture conservation and possessing, also, the greatest economic value. It may be observed, further, that the vegetation for use in the more humid regions is far more numerous and varied in kind than that available and adapted for use in the drier regions. These facts emphasize the necessity of exercising greater care in the selection and planting of all material to be used in the drier regions, if any degree of success is to be attained. The grasses have proved to be the type of vegetation best qualified for all around use in the conservation program.

Throughout the western Great Plains, where dust-storms have been making history and where crop failures have occurred year after year, a vegetative cover is sorely needed and insistent demands for buffalo grass are heard. From the standpoint of erosion control, palatability, nutritive value, and ability to withstand extreme conditions on the heavier soil types buffalo grass is without a peer. It is hoped that by pointing out some of its valuable assets a greater number of people will become acquainted with some of the interesting facts concerning this valuable plant.

Adaptability.—Buffalo grass may be found from Texas to South Dakota and from the ninety-eighth meridian west to the foothills of the Rocky Moun-

[1] Associate agronomist, Soil Conservation Service.

Buffalo grass forms a dense mat, if not mowed or grazed.

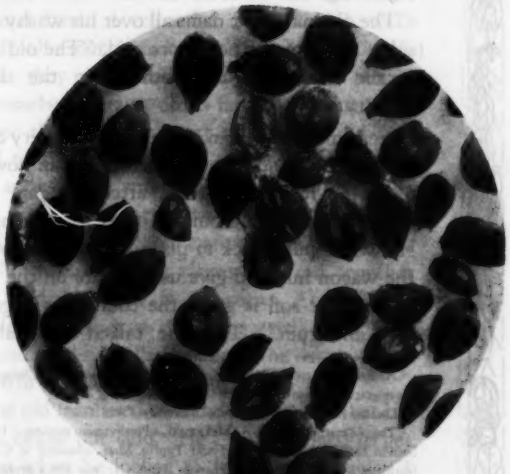
Burs produced by female plants (× 5).

tains. It is particularly well adapted to the heavier soil types.

Economic value.—Under a wide range of conditions buffalo grass will yield at least as much forage as any other grass throughout its range. It is highly nutritious and palatable during all stages of growth and even when it is dry and brown.

Type of growth.—Buffalo grass under favorable conditions will reach a height of from 3 to 6 inches. It is a stoloniferous long-life perennial, sending out runners which root at the joints and send up new plants. It is dioecious (produces both male and female plants). The blades are fine, numerous, slightly pubescent, having a tendency to curl, forming a very dense top growth.

Seed habits.—Seed, or small burs, are produced by the female plants on the stems near the surface of the ground. The burs are composed of one or more parts, usually two or three, each of which may or may not contain a caryopsis. The bur, or coat surrounding the caryopsis, is composed of a tough fibrous material which is no doubt a protective covering for the small seeds during periods of extreme conditions such as



Seed or caryopsis removed from the burs (×5).

often prevail where buffalo grass is native. Seed, or burs, do not mature uniformly like seeds of other native grasses, but are produced throughout the season during growth. This would indicate that har-

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The Soil Builder

By Angus McDonald [1]

OUR farm [2] was one of the poorest and hilliest in eastern Oklahoma. The old man [3] called it his rock and air farm.

The old man was a fanatic. He was a fanatic on soil conservation. He was always telling his neighbors how they should plow their crops and they were always laughing at him. They laughed at him because he was a preacher and he was telling them how to farm. He had queer ideas about the way to plow in dry weather, about hillside plowing, about building dams in the gullies and draws, and about conserving the soil in other ways.

The old man was a fanatic about the land. He was aways talking about Jefferson and his great agrarian philosophy of government and about Jefferson as conservationist.

"The soil," the old man said, "is the backbone of the Nation. If the soil washes away the country will go to rack and ruin."

The old man built dams all over his washy hillsides. One of the neighbors said, "The old man is the damnedest dam builder in the damn country."

I remember the old man built his dams very carefully. He would instruct the hired man how to place the rocks, and then, after the dam was built, tear it out and build it over to suit himself. He would put a rock in place, "hist" his foot on the wagon hub and give us a lecture on the soil. "When the soil is gone, the country will go to rack and ruin." Then he talked some about Jefferson and then some about Scotch contour plowing. But nobody listened. What was the use, when we had heard it so many times.

His Method

"You must always make a solid wall of rock across the gully", the old man said. "Fit the rock together and use the big ones first. Then back of the wall put the small rocks up the hill as an approach. For a small gully a 2-foot approach is enough. The little rock should be filled in until they are almost level with the top of the rock wall. Then heavy gravel or fine rock should be spread over the approach as a finishing coat."

We often tried to slight our work and throw the rocks in any way. But he would see us and make us do it over again. Will said that the old man watched us out of the corner of his eyes so much he was going blind.

The old man used a peculiar kind of hillside turning plow which he had invented or gotten somewhere. I have never seen one like it. There was a bolt and slide which turned the blade so that in turning land he could come back in the same furrow without going up and down the hill.

Aerating the Soil

Frequently when breaking land the old man used what he called a subsoiler. He ran this in the furrow behind the turning plow. A long keen bull tongue was attached to a Georgia stock. He said that this let the air get down into the soil better.

"Cotton," the old man said, "has ruined the South. It has impoverished both the land and the farmer. I am proud," he said, "that I have never raised a stalk of cotton."

The old man believed in raising lots of feed crops, particularly legumes and keeping plenty of stock to enrich the land with their manure. He

[1] Assistant soil conservationist (erosion history), Division of Climatic and Physiographic Research, Soil Conservation Service.

[2] Located near Sallisaw in Sequoyah County, Okla.

[3] The old man was Dr. J. A. McDonald, a Presbyterian minister. He was born in 1850 in Alabama, reared near Tupelo, Miss., educated at Coopers Institute, Mississippi, and at Lebanon, Tenn. He was not a professional farmer, never farmed except when he lived on the farm referred to here (1912–1922). As he read widely he probably picked up his ideas in various places. However, I have heard him say that some of his ideas had been in practice in the family for generations.

said that the farmer who bought his feed was a disgrace to civilization. The farmer should raise everything he eats except sugar and coffee.

All the farmers around let the ground near the fences and in the corners go to waste. He used every square foot of his land. He said that the richest soil was next to the fence because it had never been abused by agricultural butchers.

To begin with, our farm was one of the poorest and hilliest in the country. "You can't raise corn on that land," the neighbors said. "Maybe not the first year but you wait. I'll build it up." "What do you mean, build it up? That land is 'pore' and thin," the neighbors said.

Well, the old man went on building his dams and after 2 or 3 years, the neighbors admitted his crops were better than theirs.

Soil Feeders

On the very thin land that had much slope he set out Bermuda grass. On all the cultivated land he planted cowpeas, peanuts, and other crops that he said would enrich the soil. He never laid by his corn without sowing cowpeas unless he already had them in rows between the corn. About the next to the last cultivation sometimes he would put a row of peas in the middle. On especially thin land I've seen him plant alternate rows of peas when he planted corn. The corn rows would be 8 or 9 feet apart and have one or two rows of peas between.

He rotated his crops a great deal. His land never had corn on it more than once in 3 years. He had it all figured out that he would put more into the soil than he took out. He was the only farmer around that got two crops a year off his land. We sowed oats in February, harvested in June, and the old man, no matter how dry it was, would always break the ground as soon as the stock had cleaned up the waste grain. Then he would plant cowpeas or some other leguminous crop.

He was always cultivating in dry weather. He said that it helped to hold the moisture and the ground would soak up more and there wouldn't be so much run-off if the ground were broken.

The old man claimed the reason he made such good yields of corn was because he plowed it every 8 days in dry weather. All the old farmers waited for a rain before they plowed. They laid by their corn when it was about waist high but I've seen him cultivate his twice after it was in silk and tassel. The other farmers laid by their corn with solid sweeps that cut the roots but he began using buzzard and open sweeps after it was up any height at all. The big buzzard sweeps that he used on a double shovel stock to lay by with hardly stirred the ground over half an inch deep.

His Theory

He had a theory about conserving the moisture which took him about an hour to explain. I remember that I used to talk to Will when he got started on it but the old man was deaf and never paid any attention. He said that the capillary continuity must be broken to keep the soil from drying out.

There were only 20 acres in the old man's original farm. I remember he had rock walls nearly all around his land. These weren't gully dams; they were just walls around the fences. I remember one side of his farm was about 3 feet higher than the land next to it. The old man used to stand by the wall and look down upon the adjacent 10 acres. There was a big gully that seemed to start from nowhere just below our land. There weren't any gullies on our side at all. Just two long slopes that ran together and formed a draw in between. About every 100 feet up the draw there was a rock dam. The silt and sand had filled in above the dams until it was 6 or 8 inches higher than below.

The old man used to stand and look at that big gully below our land. He always seemed to get angry when he looked at it. The gully was 5 feet deep in some places, I guess. It ran about 50 yards from the edge of the 10-acre field. The

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CHOOSING THE RIGHT TREE[1]

By A. E. Rupp[2]

This once spectacular gully in Illinois illustrates extreme fundamental change in site conditions since original climax forest.

Up to this time the Soil Conservation Service has planted approximately 400,000,000 trees and shrubs on more than 200,000 acres of eroding land—a substantial contribution to the program of soil and water conservation.

Tree-planting, whether on a large or a small scale, is not simple. And an achievement of such great magnitude as this necessarily involves a multitude of factors and problems, not the least of which is the selection of species.

Cultural practices which permit uncontrolled washing of sloping lands have transformed hundreds of thousands of once-fertile acres into eroding wastes. Here the productive capacity has been greatly impaired, if not entirely destroyed. Afforestation appears to be the most feasible means of restoring soil productivity, through the process of building up organic matter.

Conditions on much of this land are such that the "climax" type of vegetation will not establish itself without cultural treatment and the application of nature's law of succession. The forester must be an ecologist if he is to understand the changes wrought by nature and by man upon the countenance of the landscape. The restoration of higher types of vegetation is the reverse of what has happened under the destructive hand of man.

Dr. F. E. Clements states:

> The solution of all problems that involve natural vegetation directly or indirectly rests upon the fact that every plant or community is an indicator of the conditions about it and hence of the causes that lead to these. However, the judgment of many individuals is more dependable than that of one and the verdict of many different kinds of plants grouped in a community is much better. In consequence, the study of the chief societies of a region affords the best measure of the climate and its possibilities, while the minor ones will reveal the significant variations of soil and topography.
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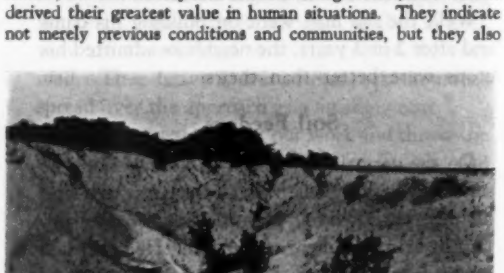
> When disturbance takes a hand, these primary indications may be greatly modified and the pattern becomes much more complex. Nevertheless, such mosaics can be disentangled by careful scrutiny, and the respective parts ascribed to climate, soil, or human interference. In a program of rehabilitation, the effect of the latter are of the most immediate importance, but they can be turned to account only as the indications of climate and terrain are understood and heeded.
>
> Fortunately, plant communities not only reflect the controlling factors, but also the sequence in which changes occur, from which is derived their greatest value in human situations. They indicate not merely previous conditions and communities, but they also forecast what will happen in the future and hence serve as the basis for control of all kinds and furnish the most satisfactory method of determining the best use of land.



Erosion arrested by bank sloping and tree planting.

Final Evaluation

The correct determination of species and cultural practices is basic to successful afforestation and will necessarily be evaluated finally by the number of living trees and the improvement of conditions conducive to soil and water conservation.

The proper appraisal of site conditions and site requirements for the species to be used is essential. It will rarely be possible to plant the climax species on the badly eroded or "problem" sites and, unless cultural treatment promises to ameliorate the adverse site conditions, we must resort to other species chosen on a basis of prevailing site conditions and tree requirements.

Afforestation has several objectives: To arrest soil losses, to conserve water resources, to restore humus and fertility, to increase farm income from trees and

[1] This is the third in a series of articles.

[2] Forester, Soil Conservation Service.

shrubs, to furnish cover for birds and animals, and to establish proper land practices.

Build Own Soil

The establishment of tree growth on eroded land will stabilize soil and thereby arrest erosion, and create woodland that will build its own nitrogenous soil.

If the soil had been left to nature and withheld from the human hand, it would have remained covered with vegetation which would have kept the soil stabilized. In the planting of trees to develop vegetative cover man cooperates with nature to stimulate and accelerate the normal work of plant life. All local factors such as elevation, exposure, the number of cloudy and clear days, the quantity and distribution of rainfall, the intensity and duration of sunlight, the clarity of the atmosphere, and the direction of the winds, must be carefully determined.

Soil Conditions

Conditions of soil must be given similar consideration. Some of these concern the physical and chemical characteristics of the subsoil. Others, such as hygrological conditions and the thickness and structure of the fertile surface soil, are based upon the topography of the soil and its geological nature. The study of site conditions leads one to a solution of the most essential part of the afforestation problem, the choice of species.

An examination of the natural local flora offers a useful aid. The disturbance of the forest by man

One year later. Black locust demonstrates its usefulness in rising to the challenge of such a situation.

usually leaves on the ground visible evidence of the primitive plant association which constitutes the nucleus from which new vegetation starts and spreads. This new vegetation, like the old, struggles against unfavorable factors and, by overcoming them gradually, reacquires the typical local form. We are thus able to estimate the state of degradation to which the plant association has been reduced, a state which faithfully reflects the condition of the soil. It also reflects which plants are best suited to the site in question, and the relative condition of soil fertility.

Often Necessary to Start Over

The natural flora may indicate a serious dearth of fertile soil, of humus, of hygroscopic water, of nutritive matter, constituting a state of physiological poverty. Under such circumstances we would commit a very serious error if we should immediately attempt to plant the same species that once thrived in the locality. Such areas lack the important humus layer. Not only the trees of the former plant association have been destroyed, but also the shrubs and perennials. It is, therefore, a matter in such cases of reconstructing the whole flora, beginning with the establishment of the forest humus by the use of those trees and shrubs which are the pioneers of the climax forest.

Every climatic zone has in its flora at least one certain species suitable as temporary or preliminary vegetative cover on the poorest soils. Among shrubs, the number of species is much larger. The species, as is to be expected, may have little commercial value but they do prepare the way for the subsequent reestablishment of a climax type of forest.

Each individual case must be studied and solved separately. Although experience teaches us that on sterile soils temporary woodland is the usual prerequisite to permanent woodland, we know that where the vegetative cover is still sufficiently thick and shows a certain quantity of humus, it is possible to undertake the direct planting of the final woodland over part of the area, if not all.

Generally speaking, we have made surprisingly little progress in establishing methods of analyzing site conditions and in the selection of suitable species for planting. The problem largely remains one for research and experimentation, but the time factor urges us to pool all available local information for purposes of immediate application.

Proof that grass holds soil and saves water was demonstrated by actual measurements taken by erosion experiment stations at Tyler and Temple, Tex., after intense rains.

Soil was swept away from a cotton field at the rate of 63 tons per acre; 31 percent of the rainfall was lost as immediate run-off, while on an adjoining field of grass only three-tenths of 1 percent of rain was lost. A field planted to Bermuda grass lost soil at the rate of only 60 pounds per acre and less than 1 percent of the rainfall run off.

THE CALIFORNIA BARRANCA

By Harry E. Reddick [1]

Barranca is the Spanish word for gully. Citizens of southern California have continued to use the word for the same reason that their real-estate men call a 10-acre plot a "rancho." Calling a 10-acre chicken-run a "rancho", or sometimes, modestly, a "ranchita", has a marked tendency to loosen the purse strings of newcomers, and one has only to look at the subdivision flags in and around Los Angeles to appreciate the psychology that has sold many a homesite in a gully with the tongue tickling nom de plume "barranca."

First Erosion Task

The California project's first task was to conquer a veritable clan of these barrancas. And it may truly be said that the arrogance of these barrancas was in full accord with that of the Spanish grandees who once lived on the land they now attack.

The royal grants that included the area now known as Las Posas often had boundary descriptions that bespoke the subtle poetry of life in carefree days. "From mountain peak to mountain peak and from Heaven to hell," read one such description, at the time when scattered fields of corn, grapes, and olives, marked the hospitable haciendas along El Camino Real, where now the price of one single acre of oranges or walnuts exceeds the value of a square league then.

[1] The author is regional conservator of region 10, Soil Conservation Service.

Originally Not Gullied

The Las Posas project contains, roughly, 30 square miles lying along the base of the foothills, some 10 to 12 miles inland from the Pacific Ocean, between Santa Barbara and Los Angeles. All evidence indicates that up until 50 years ago it was a rich, alluvial plain, where stockmen could travel miles on end without once encountering a depression of sufficient depth to hide a rider on a horse. The soil was rich, unusually deep, and covered with a dense growth of sage, or in the spring with a quilt of yellow and gold patchwork, where the mustard grew head high, or myriads of wild poppies painted the slopes.

Climatically, it was considered a part of the great southwestern desert, fit only for stockraising, with occasional fields of beans, corn, or chilies on the outskirts of a peon's adobe home. It is a region where the average rainfall is less than 14 inches, 90 percent of which falls during the 4 winter months from November through February. To say that it never rains before or after these months would be an error, but to say that it is likely to would identify one as a new-comer. This was the picture when the empty-pouched and disillusioned gold seekers of the late fifties bought plows, and returned to the tilling of the soil to make their fortunes.

High Valuation

Today the Las Posas project of approximately 20,700 acres has an average value of $626 per acre, and that does not make allowance for the fact that approximately 8,000 acres, or 40 percent of the included area, is too mountainous for agriculture.

Slashing down through the lower, more productive slopes are no less than 11 of these barrancas, with widths frequently exceeding 100 feet, and depths frequently exceeding 75 feet—11 huge cracks that crease the surface of the land in less than 12 square miles of area.

What have 50 years of agriculture and 50 years of growing barrancas done to this one locality? Fifty years of modern agricultural methods have changed this land from one of semidesert, devoted largely to grazing, to an extremely rich agricultural community where prosperous farmers grow lima beans, English walnuts, oranges, and lemons on land that pays a 10 percent dividend on an average value of $1,500 per acre in the tillable areas.

Barrancas Work Fast

The barrancas, however, have kept pace with the rise of agriculture. The barranca family of Las Posas has actually taken out of cultivation 775 acres of land with a total value exceeding $775,000, and is certain to take soon, if not stopped, an additional 525 acres worth $525,000. With but 4 months of each year to make use of run-off from the fields as a destructive force, this barranca family, starting from scratch 50 years ago, has bodily removed and transported from this one area alone an amount of dirt equal to a canal 18 feet deep, 50 feet wide, and 25 miles long.

One acre out of every 15 of the agricultural land in this area has been turned over to ground squirrels, gophers, and other rodents that wax fat on the crops along the banks. Eleven great ditches have sapped the moisture from the fields where moisture is always at a premium. This is the criminal record of Senor Barranca and his clan in but one California community.

View of once worn-out hillside on Freund farm, taken during period of drought in June 1936. In foreground may be seen orchard trees and meadow, interspersed with strawberries and garden crops. Through the center run rows of grapes and beyond them corn, alfalfa, oats and corn, berries, alfalfa, oats, alfalfa in strip arrangement.

FIFTEEN YEARS OF SOIL-BUILDING

A lot of Ohio farmers have waited for the Soil Conservation Service to point out basic principles of saving the valuable topsoil on their farms, but this is not true of Karl Freund, Belmont County. About 15 years ago he adopted soil-saving and soil-building practices on a worn-out hill farm. As a result, his land is much better today than it was 15 years ago.

Although he follows practices recommended by the State Extension Service, Freund brought some of the same ideas from Germany, from which he emigrated a decade and a half ago. Among the methods brought from the Old World are strip-cropping, liming, fertilizing, and rotation. By following these practices the Freunds have been enabled to improve upon their original investment and to purchase an additional tract of hill land for pasture.

"This farm wasn't much good when we came here", Carl Freund, the son, explained. "Those hillsides wouldn't grow much. The only good land on the place was that little piece by the barn", and he indicated a one-tenth-acre garden patch. "But look at the slope there now", he continued, waving toward a sizeable hillside, growing luxuriantly to strips of alfalfa, oats, corn, and berry patches, "it will grow anything."

One secret of rebuilding their 33-acre farm lay in proper manuring and liming. The Freunds quarry limestone on the farm and burn it in a specially constructed kiln, quite unlike the usual method of burning in beds. This idea came from the old country, as did Freund's confidence in strip cropping, which enables him to prevent loss of soil and water through erosion on steep fields.

A CLOSE-UP OF BUFFALO GRASS

(*Continued from page 49*)

vesting should be delayed until late in the season if the maximum yield is to be obtained.

Germination.—Results from germination tests have ranged from zero to 95 percent, depending upon the methods used. When the caryopsis is removed from the bur, a higher and more rapid germination takes place. Burs planted in soil and subjected to chilling over a period of 30 days have given 67 percent germination.

Harvesting of seed.—Seed has never been harvested in quantities, and no accurate information is available on yields per acre or cost per pound of harvesting. In the spring of 1935 the Soil Conservation Service recognized the value of this particular species and a determined effort was made to devise a means of obtaining seed in quantities, and of gathering information on yield per acre and cost of harvesting. The seed being produced so near the surface of the ground and the fact that it drops to the ground upon maturity, presented a real harvesting problem. An experimental vacuum machine was designed for the purpose of harvesting seed of this grass, a description of which appeared in the January 1936 number of SOIL CONSERVATION. Experimental information indicates that this method of harvesting seed may become economically feasible.

Vegetative plantings.—As previously pointed out, buffalo grass is stoloniferous, which makes it possible to establish the plant vegetatively. Under favorable conditions it will spread quite rapidly, eventually covering large areas. The rate of spread depends upon many factors—size of cubes used, soil types, degree of fertility, moisture, competition with weeds and other plants, temperature, whether or not the grass is cut, grazed, or injured by the tramping of livestock.

This Farmer Looked Ahead

The possibilities of establishing a sod or of obtaining a vegetative cover upon a cultivated field may best be indicated by citing an example. In 1930, and that was before the establishment of the Soil Conservation Service, a farmer in western Kansas wished to establish a buffalo grass pasture in a field near his barn that had been cultivated for a number of years. He took a plow and made furrows across this cultivated field approximately 10 feet apart and 5 inches deep. An old, little used township road ran along one side of the farm and buffalo grass had overgrown it. This farmer, with the help of a boy, plowed out long strips of sod, approximately 12 inches wide and 4 to 5 inches thick, cut the strips into squares, hauled them to his furrowed field and dropped them in the furrows, 12 to 15 feet apart. The square sods were not rolled or pressed into the ground but loose dirt was banked around the edges of each square. This farmer with the help of the boy, spot-planted 10 acres in one farmer's-day. The field was ungrazed for 2 years, and stolons emerged from each side of the sods, gradually filling in and covering the broad intervening spaces. So promising were the results after 2 years' observation that the farmer increased the plantings to 25 acres. In spite of the fact that favorable growing conditions have not prevailed for any long periods of time since the sods were planted, this farmer now has obtained almost a complete cover. Today he can boast of 25 acres more buffalo grass—the kind he desires most of all for his livestock. Many farmers now possessing a small acreage of buffalo grass could very well profit by this experience. They would not permanently damage their pastures because the area from which the sods were removed would soon recover itself under a brief period of favorable conditions.

There are arguments for and against such practice but this specific example illustrates what can be done, for the benefit of those who wish to attempt such a practice upon a small scale.

One other possibility is that of obtaining seed and using it alone or in mixtures with other native species for the purpose of getting it reestablished and providing a good vegetative cover. As most of us know, the south-central Great Plains, and especially the Dust Bowl, have been blessed with several good rains, reaching flood stages in some instances, while the north-central Great Plains are experiencing the worst drought in history. With these several good rains coming in the south-central Great Plains, another practical example is in order.

In Deaf Smith County, Tex., which is almost centrally located in the dust region of the Southwest, comes the following report:

In 1931 a farmer plowed up his buffalo sod and seeded wheat; the same field was put into wheat in 1932 and again in 1933. In 1934 the seed bed was prepared but the wheat was not planted. In 1935 half of the field was prepared for wheat but not planted. In May 1936, by actual count of plants in given units of ground, an average of 15 plants per

square foot was indicated, 25 percent of which were buffalo plants coming from seed.

We know comparatively little about our vegetation, especially our native grasses. Most of our commercial plants are introductions, and some very excellent types of vegetation are being sent to us each year from away, but here is buffalo grass, native to the Great Plains, and it meets all the requirements for erosion control. Demand for it is greater than for any other species. It is more persistent and will survive under extreme conditions and rough treatment. Once established, it is better than any other native grass throughout the range of its adaptation.

Seed requests for buffalo grass have outnumbered those for any other species. This alone should be sufficient evidence of its value. Seed is not yet available and substitutes must be used for the present. However, in the light of recent developments, the time is not far distant when this grass may be re-established successfully on the heavier soil types in the Great Plains.

For additional experimental information, the work of D. A. Savage, agronomist, Division of Forage Crops and Diseases, United States Department of Agriculture, is cited in Circular No. 328, Methods of Reestablishing Buffalo Grass on Cultivated Land in the Great Plains.

WITHSTAND POUNDING

(Continued from page 43)

great amount of water being concentrated in streams so rapidly that all of it cannot be carried off normally. While erosion-control measures cannot be expected to hold all the rain where it falls, it is not unreasonable to believe, thinks Mr. Du Puy (and there is experiment-station data to support his judgment), that if all the land in a watershed area were under an intelligent erosion-control program, sufficient water would be held out of the streams, or fed into the streams gradually, that flood hazards would be greatly lessened.

Other erosion-control projects in Texas are located at Garland, Temple, Lindale, Nacogdoches, Mt. Pleasant, San Angelo, and Dublin. There are, in addition, 27 soil conservation C. C. C. camps in the State.

After seeing at first hand the manner in which erosion-control measures on farms in the Plum Creek project area protected the land from washing and cutting under almost unprecedented rainfall, I am convinced of the practicality and vast potentialities of the Soil Conservation Service which has pointed the way so clearly here in Texas.

STILL USEFUL AFTER 75 YEARS

There is a perfectly sound black-locust fence post on the Jarrell Jarrett farm in Jackson County, Ga., that has been in use more than 75 years. Before the Civil War the post was cut and set and a gate swung on it for years.

Still well preserved, the post today continues to serve a useful purpose in a woven wire fence.

Grows Rapidly

One of the fastest-growing hardwood trees, black locust is used extensively by farmers cooperating with the Soil Conservation Service in the control of erosion. Planted in gullied areas or on unproductive land where the topsoil has been removed, the trees are of help in preventing further damage from washing.

Under favorable conditions, the locust grows rapidly and yields durable fence posts in 10 or 12 years. Trees 30 feet high and 5 inches in diameter are often grown in 15 years.

A Legume

Black locust is a legume, capable of adding fertility to the land. The wood is heavy, hard, very durable. Its lasting quality is recognized by its popularity for fence posts.

Soil conservationists recommend planting it as a factor in gully control, and for the enrichment of soil in other badly eroded areas.

Locust reproduces freely from root suckers, stump sprouts, and seeds. Spring is the best time for planting but seedlings may be set out in the fall.

STOCK PONDS

(*Continued from page 47*)

water needs of livestock vary with the character of feed and the weather conditions, but average about 10 gallons a day for cattle and horses, and 1 to 1½ gallons a day for sheep and goats. A reservoir for temporary use to augment other sources of supply during dry seasons need not be so large as one for permanent use. If reservoirs are filled from streams which flow much of the year, or from washes where frequent flows occur, a basin of smaller capacity is required than when flow is limited to short periods. The importance of seepage and evaporation losses and methods of reducing them have already been discussed. Loss of water from both these causes must be allowed for by increased capacity of the reservoirs. Allowance should also be made for loss of capacity by silting.

Earthen dam built by Soil Conservation Service in Missouri in fall of 1934; depth, approximately 7½ feet; capacity, approximately, 14,000 gallons.

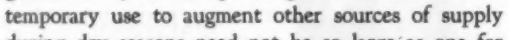


Table showing differences between evaporation during an average year and a drought year in the Great Plains

[Data from U. S. Bureau of Plant Industry]

Station	Evaporation, April–September, 15-year average, in inches	Evaporation, April–September, 1934, in inches	Difference
Havre, Mont.	35.32	44.06	8.74
Moccasin, Mont.	34.29	43.31	9.02
Dickinson, N. Dak.	34.63	47.03	12.40
Mandan, N. Dak.	34.18	40.75	6.57
Ardmore, S. Dak.	37.64	49.62	11.98
Archer, Wyo.	36.52	43.95	7.43
Sheridan, Wyo.	34.42	40.38	5.96
N. Platte, Nebr.	39.33	55.34	16.01
Garden City, Kans.	54.67	70.53	15.86
Hays, Kans.	46.01	66.35	20.34
Colby, Kans.	41.77	57.45	15.68
Akron, Colo.	43.73	52.62	8.89
Lawton, Okla.	43.63	57.85	14.22
Dalhart, Tex.	48.08	61.13	13.05
Big Spring, Tex.	35.99	62.28	6.29
Tucumcari, N. Mex.	54.52	67.22	12.70

THE SOIL BUILDER

(*Continued from page 51*)

land between the gully and the fence had grown up with sassafras, red oak, and hickory bushes, and there were some blackberry thickets in some places. The rest of the land was in cultivation and was streaked with a few little gullies but most of it was nearly flat and the soil was reddish yellow. The old man said it was an example of what sheet wash would do.

It finally got so the old man would wander over to that side of the field and look at the gully and the washed land more and more. One day he climbed over the fence and stomped up and down between the rows of stunted cotton and began talking to himself. I heard him mutter something about the foundations of civilization being undermined. I thought probably he was getting up one of his sermons.

Reclamation Begins

It was not long after this that the old man bought this adjacent 10 acres. One of the neighbors told me that he had given two prices for it. I have never seen anybody work so hard as the old man did that year. He had the bushes all cleared off the new land in no time. Then he started to work on the gully. Will told me he was going to quit. He said he wasn't going to kill himself for no dollar a day. We hauled rocks by the wagonload and built great walls of rock across the gully. Then the old man filled in behind with brush, blackberry-vine stems and little rocks. Behind the initial wall he laid heavy tow sacks. I had never seen him take so much care. Along by the fence he had a ditch dug to take care of the surplus water.

Right after the dams were completed a big rain came and the water tore holes in the dams in several places. But the old man was out early the next morning and put all the rocks back in place and strengthened the weak places.

He planted the poor part of the field in cowpeas, had us pick the peas when they were mature and then turned the vines under. In 3 years' time you wouldn't have known it was the same 10 acres. The gully was nearly filled up and we were plowing over it. All the rows of the forage crops were run on the contours of the slope and there was little or no wash even during big rains. The soil looked darker and every year the yields were larger than the preceding one.

The old man died in 1924. I went to the funeral service in a church in Fort Smith where once he had been the pastor. The minister told what a good man he was and how many souls he had saved. He didn't mention the soil he had saved.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

ELEMENTS OF GEOGRAPHY. By Vernor C. Finch and Glenn T. Trewartha. New York and London. April 1936.

It is almost 2,000 years since a Roman man of letters, Marcus Tullius, known forever after as Cicero, referred in his De Natura Deorum to the age-long quest for the laws of life, the principles of existence, and the relation between the planet Earth and the phenomena of the elements: "The beauty of the world, the order of the celestial system, the revolution of the sun, of the moon, of all the stars, indicate sufficiently, at a very glance, that all these things are not accidental."

Since the day of Cicero, so much factual knowledge has accumulated concerning the earth's land regions, the gaseous envelope called atmosphere, and the depressed segments of the earth's crust, which are filled by the oceans and the great seas, that men safely explore the poles, climb the stratosphere, descend the deepest depths of the sea, and the authors of this book of 782 pages state in all humility that their work is merely "in the nature of an introductory handbook the contents of which should facilitate the observation and study of regional phenomena."

In its approach to the study of Earth's regions this new book presents an analysis of natural features or elements, more especially those having significant relationships to character of land utilization. Nature and distribution of material features existent in the present age are emphasized, rather than origins or processes of formation, although the latter are not neglected. As an illustration: stream origin and development does not receive the same extended treatment as do such stream features as delta plains, alluvial terraces, and stream erosion.

At the outset this text presents three chapters which are introductory in form and structure. Herein the field of geography is defined, earth motions and planetary relations are outlined, and a study of maps and their interpretation proffers the essential tool of the geographer.

The study of climate, the major element, is approached through a consideration of elements and processes of the atmosphere. Through a grouping of knowledge concerning sun energy and atmospheric temperatures, general features of temperature distribution over the earth's surface, winds and atmospheric pressure, the planetary system of winds, atmospheric moisture and precipitation, and storms and their associated weather types, the student is prepared for the subject of separate climatic types and their distribution. An interesting feature of the chapter on atmospheric pressure and winds is a discussion of a wind system as it might develop on a homogeneous nonrotating earth with maximum solar energy received at the Equator. A study of ocean drifts and currents from the viewpoint of climatic significance is also included in this chapter.

The general scheme or outline of climatic type subdivisions follows Köppen, with reference, for advanced study, to the world classification of climates emphasizing numerical values of temperature and rainfall for defining boundaries of climatic types, by Dr. Thornthwaite. Each climatic type—tropical rainy, dry humid, mesothermal, humid microthermal, polar—receive special treatment as to location and boundaries, precipitation, temperature, winds, daily weather, seasonal weather, and local variation.

The study of land forms is approached through a brief survey of the materials of which they are composed, the processes by which they originate, and the agents involved in their origins. Important earth elements and surface molding forces, tectonic and gradational, are treated with special emphasis on plains of stream gradation and glaciated plains, shore features of plains, plateaus, hill lands, and mountains. Of particular importance is the section of the book, consisting of approximately 100 pages, which treats of plains. Highly important, too, from the standpoint of the soil conservationist, is the comparative roughness of plains. This element of roughness is significant because indicative of various aspects of human utility of plains, such as the freedom of drainage, rapidity of soil erosion, or the ease of tillage. Of interest are the karst plains, variously distributed over the earth, surface features of which result from the solvent work of underground water. Region such as this are underlain by sediments which include layers of pure limestone. Instead of stream-eroded drainage patterns, karst plains have undulating, rolling, or sometimes rough surfaces in which numerous depressions without visible outlets are separated by low, irregular ridges or hillocks without definite pattern of arrangement. The depressions, generally called "sinks", are associated with underground drainage. Notable among the karst plains in the United States is the undulating to rough region in south central Kentucky, which is underlain by cavernous limestone. Considerable parts of this region are so dominated by solution features that sinks and their associated knolls and ridges are the principal relief features. Under primitive forest conditions many, if not most, of the sinks had free underdrainage. Since clearing, soil erosion has stripped clay from the adjacent slopes and deposited it in sinks until they are now ill-drained and contain at least temporary ponds. No mention is made in this text of the large spectacular sink enclosing a lake of deep blue water of unknown depth, called locally Montlake, which is located on the Cumberland Plateau near Chattanooga, Tenn.

The section of the book on earth resources contains elementary treatments of water resources, original vegetation cover and associated animal life, mineral fuels, ores, and other economic minerals, and, in outline form, the fundamentals of soil chemistry, soil physics, and soil classification. At the close of a chapter describing the principal soil groups of the world, the subject of destructive erosion is treated briefly but convincingly. Three Soil Conservation Service photographs are included, showing land with incipient gullying, a cultivated slope that has been badly damaged by gullying, and Mr. Bennett's own photographic masterpiece, originally published in Geographical Review, showing a field with soil completely destroyed for agricultural use by unchecked gullying.

The second part of this volume is, in its content, unique among American textbooks of geography. It deals with material culture, and

is a classification and outline study of the types of features resulting from human activities in the various regions of the world. It involves density and distribution of population; houses and settlements—rural villages of the Far East, the market town, the city; the distributional pattern of agricultural land—rice in the river floodplains of Ceylon and coconut groves on the interfluves; multiple cropping and interculture in Japan and Italy; livestock per square mile, per 100 acres of crop land—or pastoral nomadism on the Asiatic tundra; farm shapes and composition; manufactural features; the extractive industries—logging, mining, fishing, hunting; transportation and terminal equipment.

Part III deals with the earth's largest geographic subdivisions, here designated as realms, and is in the nature of a regional synthesis and summary of those features of the natural earth which previously were discussed individually and analytically. Emphasis is upon regional integration of the several natural elements. They are studied as interrelated component parts, areally associated. In this study of realms, emphasis is placed also upon an evaluation of the resource endowments or natural equipment of each realm for human use.

The five geographic realms (humid tropical, dry, humid mesothermal, humid microthermal, polar) are treated separately as to location on the earth's surface, climate and climatic influences upon human beings, vegetation resources, soil resources, landforms and drainage, and regional aspects. The subject of run-off and soil erosion is treated briefly in dry-realm association.

The appendix contains supplementary climatic data for selected stations; a selected list of United States topographic quadrangles; and an excellent chart of Earth's history as recorded in the rocks of North America. The book is rich in illustrations selected with the special purpose of centering attention upon significant features under discussion. The pocket plates accompanying the book have been prepared in blank, and are intended for student drawings and coloring as a manual aid to the appreciation of significant facts and associations in the distribution of earth's phenomena.

Reference lists are appended to those chapters, sections, or parts of the book that treat of distinct fields, and are intended to suggest some of the more recent of the authoritative general works in each field.

California barranca being straightened by C. C. C. workers. The old one overflowed during rainy season and caused heavy silting in nearby orchards.

PEDOLOGY. By Jacob S. Joffe. 1936. Introduction by the late Dr. Curtis F. Marbut.

In this book the American pedologist may have opportunity to familiarize himself with the history of the development of pedological science in Russia, which fact alone makes it an important contribution, for, as is set down in the introduction by the late Dr. Marbut, "It was Russian work which brought the study of soils out of chaos and confusion of the geologic, agronomic, chemical points of view and established it firmly as an independent science with criteria, point of view, method of approach, processes of development applicable to the soil alone and inapplicable to any other series of natural bodies." And it was Russian work which determined a definite relationship between the soil and the environment in which the soil is found, thus showing the soil to be related, on the plane of development, to biological bodies and not wholly physical.

At the outset Professor Joffe discusses pedology as a scientific discipline, coordinating it with, and at the same time separating it from, the other earth sciences—chemistry, geography, physics, geology, etc.; and from thence progresses to practical and cautious presentation of the subject of soil morphology. In this section of the book, wherein are given detailed directions for studying and sampling the soil, the author states that some of the morphological features, such as color, structure, and distribution of constituents in the profile, lend themselves to experimental verification in the laboratory.

Under the heading, Soil Genesis, Professor Joffe treats of weathering and soil formation; soil-formers, passive and active; and soil-forming processes. The summary of Schmuck's ideas on soil organic matter is given, and also Kurilov's table showing the relation of humus to mineral content of soil.

In an extensive treatment of the subject of soil systematics, soils of the world are grouped according to formation—desert, semi-desert, and arid; chernozem; podzol type with subtypes and transition types in the podzol zone; tundra; laterites and lateritic type; intrazonal; bog and marsh; mountain soils. In the section treating of chernozem soils the author presents the views of various pedologists concerning the prairie soils which border the eastern edge of the meridianal belt of chernozem soils in the United States. In his discussion of soils of the prairie province, Professor Joffe has this to say, "Since characteristics point to the degradation process, one cannot help but place the prairie soils into the subdivision of the degraded chernozem" [this view is opposed by Dr. Marbut, and he expresses his reasons in the introduction of this book] "the inherent nature of which is a somewhat leached condition with all its accompanying effects, among which are the shifting of the lime zone deeper into the profile and to ultimate disappearance as the podzol process of soil formation predominates. Whether or not the prairie soils that show no lime zone will ever become more podzolic is a debatable question. A solution to the problem lies in establishing the balance between the outgo and the return of bases, in the alkaline earth in particular. A practical approach to the experimental solution of this problem has been suggested in connection with a discussion of the status of some podzolic soils in the great podzol zone. The lysimeter method of studying the leachings and an analysis of the incoming materials are the salient features of this approach." Glinka's tables showing composition and water extract of meadow land soil from Seja Bureja, Amour Region, are shown in connection with the study of bog and marsh soils.

In his final chapter Professor Joffe gives a brief history of soil studies in the United States, beginning with the inauguration of the Soil Survey in the early nineties, and including Dr. Marbut's scheme of classification by categories with a discussion of pedocals and pedalfers as "the one novel feature which brings the grouping of the soils of the United States by Marbut one step closer to a harmonious system."

The book has nearly 1,000 references, much tabulated data, adequate illustration, and both subject and author index.

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